

Astronomy 490

The Salvation of the Yggdrasil
An Astronomy Adventure Course
Spring 2024



Course Information

Instructor: Dr. Sean Lindsay Email: slindsay@utk.edu

Location: Room 306 in Nielsen Physics and Astronomy

Meeting Time: Tuesdays and Thursdays from 4:05 - 5:20 pm

Practice/Discussion Hours

Mondays 2:00 - 3:00 pm

Thursdays 10:30 am - 12:00 pm

Fridays 10:30 am - 12:00 pm

Course Website: <https://sites.google.com/utk.edu/astronomy490utk/home>

Course AIs

Sága, Your AI Research Helper: [Link to Sága](#)

Steven - Fractured, What Remains of Steven: [Link to Steven](#)

Course Portfolio Tool: [Google Sites](#)

I created the course website using Google Sites. It is quick to learn and use.

Course Schedule (Work in Progress) - [Astronomy 490 Course Schedule](#)

Course Slack: [Invite to Astronomy 490 - SoTY Workspace](#)

Course Description

Astronomy 490 is a class that focuses on using astronomy to develop problem-solving, critical thinking, and collaboration skills. It aims to provide context to how what is learned in class can be used to address interesting questions and problems. This is accomplished through a series of projects designed to encourage curiosity, creativity, and critical thinking. The class mainly uses a science fiction storyline, "The Salvation of the Yggdrasil" to engage students in an immersive astronomy experience. The storyline plays out over three chapters, where each chapter

presents a challenge to overcome that requires application of the astronomy and physics concepts learned in class to progress the story.

The Yggdrasil is an intergenerational spaceship on a 300-year journey to bring humans to a habitable planet in orbit around an alien star. In the 178th year of its journey, the Yggdrasil is struck by an asteroid-like object leading to the loss of most of its hydrogen reserves it uses to power its hydrogen fusion engines and generators. You will play the part of a Yggdrasil citizen who must figure out how to collect more hydrogen from a nearby star before the ship goes dark. Using the astronomy and physics you learn in this class, can you save the people of the Yggdrasil?

Student Assessment & Student Portfolios

Background

This class uses non-traditional assessment methods. Instead of the normal graded student work (homework, quizzes, exams, etc.) with an assigned numerical and letter grade, most of the work in this class will be self- and peer-assessed supplemented with instructor feedback. The goals for this method of assessment are: 1) you do the work for yourself and not for the instructor; 2) remove the extrinsic motivator and stressor of numerical scores; and 3) make room for reflection and practice instead of performance and judgment.

Expanding on (1), I have most often seen student work where the student is attempting to guess at what the instructor wants, or are most concerned with getting an answer then they are about the process and practice of developing problem-solving skills. I promise you that in this class, I am not quietly taking notes so that I can judge you. I want you to learn what quality work looks like for you. I want you to learn how to go one step further because you are interested or enjoying the work.

Expanding on (2), there have been numerous studies done on student learning and motivation that point toward a common theme: grades (letter and numerical) undermine the goals of learning while promoting performance and regurgitation. This leads to maximizing the system to get the A and a high GPA. The pressure to do this is ever increasing as the requirements to get a job or into graduate school become more demanding. In doing so, we are teaching students to be performers rather than learners. I want this class to be an opportunity for you to learn how to learn, and hopefully fall in love with the idea of being a forever learner. (See Blum, 2020 and references there-in for further reading)

Expanding on (3), I want to make room in this class for you to think about your thinking and problem-solving processes. To become better at problem-solving and critical thinking, we need to understand how we approach problems while also learning strategies to break problems down into manageable parts. We need room to make mistakes, and the opportunity to learn

from them. Reflecting on our notes and work helps us identify our strengths, weaknesses, and how we might go about improving aspects of ourselves that we want to improve.

Self-Assigned Grades

Here at the University of Tennessee, instructors are required to report a letter grade to the university for every student in every class. This is an unfortunate reality given the research showing the negative effects grading has on learning. One method to get around this while also adding value to the learning process is ***self-assigned grades***.

At the end of the semester, we will have a one-on-one meeting where you will tell me what grade you earned in this class and then justify it.

You will track your progress through the semester by making a Google Sites student portfolio. On your Google Sites website portfolio, you will post all of your weekly reflections, project reflections, peer evaluations, and major project products. Prior to our end of the semester meeting, you will complete a Portfolio Reflection, which is designed for you to review your work and reflect on what letter grade you think you have earned.

More than anything, I am looking for signs of development and growth. If you are honest with yourself, your work, and the process, then there should not be a need for negotiation between us about your grade. ***I reserve the right to adjust grades down and up in cases where your work is not reflective of your self-assessment.*** Imagine how hard it would be to do little or low-quality work, and then look me in the eyes and say you earned an A. Imagine how hard it would be for me to give you a grade of a C when I think you earned a B or an A.

Meetings with Dr. Lindsay

You will have three one-on-one meetings with me and one group report meeting with me during this class. The one-on-one meetings will happen during Week 5 (1st Meeting), Week 11 (2nd Meeting), and during the final exam period (3rd Meeting; Thur., 9 May through Wed., 15 May). The first two one-on-one meetings will be to check in and discuss the class, the current projects, your goals, etc. The last one-on-one meeting will be when you tell me the grade you assigned yourself and your justification for earning that grade. The last meeting will also serve as a coda for the course where we can have a fun chat.

The group report meeting will be your group walking me through one of your Chapter Reports for a solution on to one of the three core Salvation of the Yggdrasil Chapters. This will take place at some point during Phase II - Salvation of the Yggdrasil (Weeks 6 through 12).

Student Portfolios

Each of you will create a portfolio where you can house all your written works and reflections for this class. The primary contributions to the portfolio will be the weekly reflections that respond to the set of given reflection prompts, your project reflections and write-ups, your Salvation of the Yggdrasil Chapter Reports, and any other work that is easily archived electronically.

We will use Google Sites to create your Student Portfolio. While limited in design and functionality, Google Sites makes up for those limitations by its ease of use and integration with Google resources. The learning curve to create a website with multiple pages/tabs is shallow. I am considering other software (Miro or Mural) for Student Portfolios in the future, so I may have a part of the class where we test those softwares in an in-class activity.

You are expected to keep your portfolio up to date. I will be accessing much of your work through your Portfolio and shared Google Documents/Sheets/Slides etc.

Link to Reflection Prompts ← That is a link

Course Learning Outcomes

- Understand simple Newtonian Mechanics, gravity, and 2-D orbits to create transfer orbits, imaginary planets, and solve for how long it takes a ship to travel through space.
- Understand the nature of light as an electromagnetic wave and photon, and how this applies to thermal radiation and spectroscopy.
- Understand how astronomers measure the distances to the stars via stellar parallax at a first principles level
- Gain practical experience with the magnitude system and stellar properties such as color temperature, spectral class, color-index, and absolute magnitude/luminosity
- Apply the nuclear fusion energy production in stars via proton-proton chain hydrogen to helium fusion to new scenarios
- Understand and apply the principles of interstellar extinction, reddening, and radiative transfer, including optical depth, number density, column density, and extinction cross-sections
- Develop open-ended problems solving skills that involve navigation through several unguided multistep problems
- Develop the skill of identifying important data/information related to your goals versus data that is not necessarily important to your specific goal.
- Develop scientific communication skills through writing chapter reports that clearly express your thought process on meeting each chapter's clear criteria.
- Explore your own learning interests through assignments that give students agency.

Primary Course Topics

Below is an itemized list of the primary course topics I hope to cover this semester. For a more detailed list of topics, see [All Potential Astronomy 490 Topics](#). I likely will not be able to cover all of these topics.

- **Simple Newtonian Mechanics:** Newtonian mechanics also includes the basics of acceleration, velocity, and travel time
- **Gravity and Orbits:** Simple Newtonian Mechanics: How do planets orbit and how can we design transfer orbits to get from one celestial body to another?

- **Light:** What is the nature of light as an electromagnetic wave and a particle? How does matter interact with light - thermal radiation & spectroscopy.
- **Stellar Properties:** How observable properties of stars translate to physical properties of stars.
- **Stellar Fusion:** How do stars produce energy through nuclear fusion of hydrogen into helium?
- **The Interstellar Medium (ISM):** What is the interstellar medium. How does the dust of the interstellar medium affect our observations of stars?
- **Radiative transfer:** What happens to light as it travels through an absorbing and scattering medium of gas and dust?.
- **Planetary Astronomy:** What factors determine whether a planet is habitable? How do astronomers determine the chemical composition of planets, asteroids, comets, and other planetary system bodies?

Expectations and Hopes

I expect every student to attend class, participate in class activities and group work, and complete the course projects. I hope to see every student develop in a number of ways through the semester. This class focuses equally on the “soft-skills” of problem-solving, critical thinking, researching, and collaboration as it does on the content. I hope to see you develop as a learner, and yes, growth and development goes a long way in your consideration and self-assignment of a grade. If you struggle at first, but then show marked improvement, then in my book, that is just as good as having high performance for the duration of the semester. Remember the goal is learning, not performing.

Major Class Projects

So You Want to Build a Moon Base

In this collaborative project, the class will undertake the problem of what is required, and what are the benefits of, building a permanent lunar habitat for humans. Student groups will choose an aspect, or aspects, of the problem that interest them, and then perform a literature search to more deeply understand the challenges, what progress has already been made, and what is still required to build a lunar habitat.

This project focuses on collaboration, learning how to navigate and understand scientific literature/technical documents, and integrating knowledge to build a prototype solution to a challenging problem we have not yet solved.

Project Deliverables/Portfolio Items

- Report on your chosen aspect of creating a lunar habitat
- Annotated bibliography
- Lunar Habitat Reflection

The Salvation of the Yggdrasil

This is the core of the Astronomy 490 class. The "Salvation of the Yggdrasil" is a three chapter science fiction scenario where students must use the physics and astronomy concepts taught in class to solve challenges. The setting is an intergenerational spaceship, called the Yggdrasil, which houses 180,000 residents. The ship is in the 178th year of its journey to bring a sliver of humanity to a new home amongst the stars when it meets with a potentially world-ending catastrophe. The ship is struck by an asteroid-like object, causing severe damage to the ship, but more critically, the disaster leads to the loss of most of the hydrogen reserves it uses to power its hydrogen fusion generators and engines. The Yggdrasil only has enough hydrogen left to power the ship for another 30 years. After that, the ship will go dark, and humanity's greatest achievement will become humanity's greatest tomb.

Do you have what it takes to guide the Yggdrasil and its people out of disaster and to their new home world? Take the role of someone, or someones, living aboard the Yggdrasil and find out.

Project Deliverables/Portfolio Items

- Chapter 1 - "The Oppenheimer-Krishna Catastrophe" Report
- Chapter 2 - "Project Icarus" Report
- Chapter 3 - "The Enveloping Cosmic Dark" Report
- Chapter 4 - Student Group Created Scenario & Solution
- Yggdrasil World Problems & Solutions
- 1 "Exploration-Oriented" Optional Chapter
- 1 "Goal Oriented" Optional Chapter
- Reflection on Salvation of the Yggdrasil

Science, Technology, Society, and Ethics

What are some of the most interesting and pressing ethical questions related to technology that our society faces today? What technology-related ethical considerations need deeper consideration, reflection, and action to move us toward a better future? Presciently, Carl Sagan once wrote in *The Demon-Haunted World*, "we've arranged a global civilization in which most crucial elements profoundly depend on science and technology. We have also arranged things so that almost no one understands science and technology. This is a prescription for disaster. We might get away with it for a while, but sooner or later this combustible mixture of ignorance and power is going to blow up in our faces."

A part of this "prescription for disaster" is a lack of public awareness and critical thought around the intersection between science, technology, society, and ethics. In this project, we will go through a design thinking process to imagine what technology could exist onboard the Yggdrasil. Once our ideas are refined, we will consider how that technology appears and is used by the people of the Yggdrasil, how it benefits their society, and what the potential harms (intentional and unintentional) may exist. We will identify interesting ethical questions related to this analysis and decide if the technology should be allowed without restriction, regulated, or banned.

Project Deliverables/Portfolio Items

- Group “On the Wall” Presentation & Response to Critique
- Written STSE Report
- STSE Reflection

Creative Class Projects

For now, I have two creative class projects planned for the class.

Add to the Yggdrasil Project

The key to this project is to find something about the science fictional Yggdrasil World (a.k.a., “The Ygg World”) and add to it. You will choose some aspect of the Ygg-World that falings with your discipline (major) or an area of deep interest to you. From there, you will imagine and describe some aspect of the Ygg World as you see it by analyzing, evaluating, and designing how your addition/topic interacts with the Yggdrasil society.

You are not limited to astronomy and physics for this project. If you want to write a short story about life on the Yggdrasil, you can do that. If you want to write a newspaper article, or articles, about something occurring on the Yggdrasil, you can do that. If you want to develop the water management system, the transportation system, food production & distribution system, etc. of the Yggdrasil society, you can do that. Are you curious about politics, economy, social structure, etc. of the ship? Then you can develop that via a written report, short story, article, wiki, website, etc.

This is hopefully a *highly interdisciplinary* project that is motivated by your own interests. It has no limitations on what you want to add to the world. Once completed, you will be given the option of anonymously sharing your addition to the class.

Leave Your History

After completing “The Salvation of the Yggdrasil” (SotY)scenario, you can begin working on this project. In this project, you will leave a journal entry of your accomplishments, challenges, and growth you experienced while going through this SotY storyline. With your permission, your history will be archived for future students to read after they have completed the scenario.

Class Artificial Intelligences

I have created two GPT AIs that are at your disposal for this Class

- **Sága** - An AI assistant specializing in off-world habitats and international space law. Sága was designed to help with the “So you Want to Build a Moon Base” project
- **Steven - Fractured** (spoilers, so text is in white. Highlight it to reveal the text)
Hidden text below

Educational Research Related to Astronomy 490

Given the novel nature of this class, I am conducting educational research related to what I am calling “deep scenario-based learning.” This class employs a number of well-researched experiential learning methods, including scenario-based learning, project-based learning, problem-based learning, and human-centered design. I am deeply invested in finding methods of educating that have students engaging in learning through intrinsic motivation, or at least internalized extrinsic motivation. I think many of us would agree that our normal methods are no longer working well to meet the needs and curiosities of people.

For me to do this in the best way possible, I need to evaluate and understand how well my methods are working, and then share the results with the educational community. This means that I am conducting human-subjects approved research for this class. Consent to participate in my educational research is an opt-in process that you will be introduced to during the semester. It is entirely optional if you want to participate in the study, and there will be no course evaluation, assessment, or judgment attached to your choice to participate.

If you are curious about the methods I am testing, and the motivational psychological theory, Self-Determination Theory (Deci and Ryan, 1985; See Ryan and Deci, 2020 for a review of SDT applied to education), please feel free to talk to me about it.

Other Course Policies

AI Policy: Permitted in this Course with Attribution

I embrace and encourage AI use in assignments, with the requirement that students disclose any AI assistance.

In this course, students are encouraged to use Generative AI Tools like ChatGPT to support their work. To maintain academic integrity, students must disclose any AI-generated material they use and properly attribute it, including in-text citations, quotations, and references.

A student should include the following statement in assignments to indicate use of a Generative AI Tool: “The author(s) would like to acknowledge the use of [Generative AI Tool Name], a language model developed by [Generative AI Tool Provider], in the preparation of this assignment. The [Generative AI Tool Name] was used in the following way(s) in this assignment [e.g., brainstorming, grammatical correction, citation, which portion of the assignment].”

Student Issues

If you have any concerns that you would like me to know about, please see me or email me early in the semester. I understand that many of you have jobs, complicated family circumstances, private personal struggles, or a whole host of other factors that could affect your performance in this course. This is exacerbated by several orders of magnitude this semester. If you can let me know early, and before it becomes a problem in the course, I am almost always happy to work with you in order to foster an optimal educational experience. Please feel free to approach me during my office hours or via email.

Student Disability Services

The University of Tennessee, Knoxville, is committed to providing an inclusive learning environment for all students. If you anticipate or experience a barrier in this course due to a chronic health condition, a learning, hearing, neurological, mental health, vision, physical, or other kind of disability, or a temporary injury, you are encouraged to contact Student Disability Services (SDS) at 865-974-6087 or sds@utk.edu. An SDS Coordinator will meet with you to develop a plan to ensure you have equitable access to this course. If you are already registered with SDS, please contact your instructor to discuss implementing accommodations included in your course access letter.

Bibliography

Blum, S.D., 2020. Ungrading: Why Rating Students Undermines Learning (and what to Do Instead). West Virginia University Press.

Deci, E.L., Ryan, R.M., 1985. Intrinsic Motivation and Self-Determination in Human Behavior. Springer US, Boston, MA.

Ryan, R.M., Deci, E.L., 2020. Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions. Contemporary Educational Psychology 61, 101860. <https://doi.org/10.1016/j.cedpsych.2020.101860>